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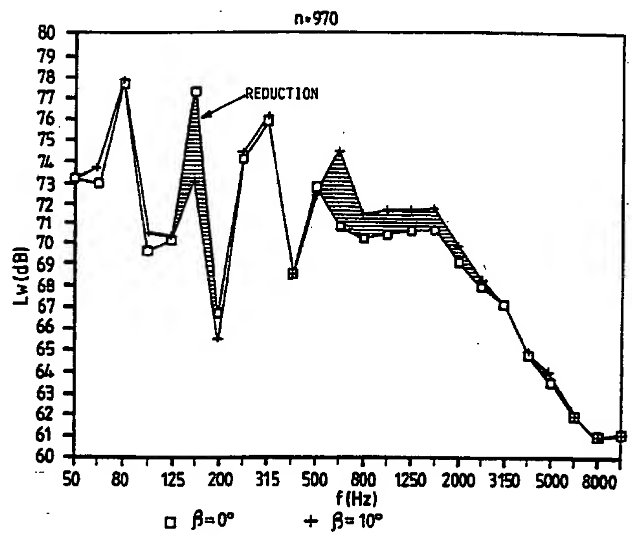

(57) Abstract

A guide vane arrangement for axial fans, intended to translate the rotational component of the gas flow velocity after passage through the impeller (1) into a substantially axial velocity, including a ring (2) of guide vanes disposed downstream of the fan and in spaced relationship therewith. Alternate guide vanes are axially displaced with respect to the remaining ones, so that alternate guide vanes are at a first axial distance from the fan and the remainder are at a second axial distance from the fan. As an alternative, alternate guide vanes have a portion of the end part facing towards the fan removed, so that the forward edge of alternate guide vanes is at a first distance from the fan and the remaining guide vanes are at a second axial distance, and the guide vanes are non-uniformly distributed along the periphery of the ring.

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GUIDE VANE MEANS

The following invention relates to a guide vane arrangement for axial fans, intended to convert the rotational component in the gas flow velocity after passage through the impeller into a substantially axial velocity, the arrangement including a ring of guide vanes disposed downstream of the fan and in spaced relationship therewith.

The gas flow downstream of the impeller of an axial fan normally rotates. The rotational energy can be translated into useful energy by a guide vane arrangement on the outlet side of the fan, this arrangement converting the rotational velocity to an axial velocity component. The pressure is raised in this way, and the efficiency of the fan increases. Normally, however, the sound level also increases at the same time.

The sound from a fan comprises tonal components, i.e. tones with discrete frequencies and a wide band noise with a continuous frequency spectrum. Considerable efforts have been made primarily to lower the tonal components, by suitable arrangement and embodiment of guide vanes on the output side of the fan.

It is accordingly a general understanding that the noise generated decreases with increasing distance between the impeller and guide vanes, see M.J. Benzakein, J. Acoust. Soc. Am. 51 (1972), 1427-1438 and W. Neise, Proc. INTER-NOISE 1988, pp 767-776. It has been found, however, this is not always applicable.

A guide vane is described in the Swedish patent 8802136-5, which has improved aerodynamic and acoustic properties.

It has also been found earlier that a non-uniform distribution of the guide vanes in the ring of guide vanes can give rise to certain acoustic improvements, although it has been found that large deviations from a uniform distribution of the guide vanes give rise to aerodynamic problems.

It is also known that certain acoustic characteristics can be improved by a portion being cut out from alternate guide van s in their the forward portions.

Fig. 1 illustrat s how th strength in an individual tone

can be reduc d by displacing the guide vanes in the circumferential directi n f the guide vane ring. It will als be seen from the same figure that the noise at higher frequencies over about 500 Hz also increases at the same time. The measurement has been made for a fan R.P.M. of $n = 970$ and a displacement of alternate guide vanes of $\beta = 10°$ and $\beta = 0°$.

The object of the present invention is to lower individual, disturbing tones in the fan sound, as well as lower the general noise level in a simple way.

The first-mentioned object is achieved with a guide vane ring of the kind mentioned in the introduction, and with characteristics disclosed in claim 1.

The second object is achieved by a further development of the inventive guide vane arrangement, in which alternate guide vanes are axially displaced relative the remaining ones, so that alternate guide vanes are at a first axial distance from the fan, and the remainder at a second axial distance, simultaneously as the guide vanes are non-uniformly distributed in the guide vane ring circumference. Preferably, alternate guide vanes are displaced in the circumferential direction relative the remaining guide vanes with a constant displacement so that the distance in the circumferential direction between juxtaposed guide vanes alternates between two given values. This arrangement reduces both individual tones and the general wide band noise from the fan. In addition, this combination of axial displacement and circumferential displacement of the guide vanes provides improved efficiency of the fan, compared with the case using a guide vane arrangement with solely axial displacement of the guide vanes, or solely rotation of them in the circumferential direction.

By the combination of measures according to this further development of the apparatus in accordance with the invention, there are achieved highly important advantages, both in respect of acoustics and efficiency, considerably exceeding the effects achieved by the individual measures of axial displacement or circumferential rotation of the guide vanes.

In accordance with an ther advantageous embodiment of the inventive apparatus, the axial displacement of the guide vanes

is in the interval 0,4 - 0,7 l/l_{ch}, preferably 0,5 l/l_{ch}, where l denotes the magnitude of the displacement and l_{ch} the length along the guide vane.

In accordance with yet another advantageous embodiment, the displacement in the circumferential direction is in the interval 5 - 15°, and is preferably 10°.

In accordance with a further advantageous embodiment of the apparatus in accordance with the invention, the guide vane ring arrangement is divided into two rings axially in tandem, alternate guide vanes being carried by one ring and the other guide vanes by the other ring, the rings being axially displaceable relative each other or radially rotatable relative each other about a common axis. It is thus possible to adjust the guide vane arrangement in a simple way to achieve optimum conditions.

In accordance with a further advantageous embodiment of the invention, in the portion facing towards the impeller the guide vanes are designed with a web configuration between the radially outer and inner portions of the guide vane such that the arcuate length along the single-curved guide vane at the level of the web is shorter than at said mentioned outer and inner portions.

Embodiments of the arrangements in accordance with the invention, selected as examples, will now be described in more detail and with reference to the accompanying drawings, where Fig. 1 illustrates the effect on the sound level from the fan when alternate guide vanes are displaced in the circumferential direction in accordance with prior art; Fig. 2 illustrates an axial fan with guide vanes arranged downstream of the fan; Fig. 3 schematically illustrates five different guide vane arrangements: a) guide vanes arranged uniformly according to the prior art, b) alternate guide vanes displaced in the circumferential direction of the guide vane ring according to the prior art, c) alternate guide vanes axially displaced in accordance with the invention, d) a combination of axial displacement and rotation of the guide vane ring in a circumferential direction in accordance with the inv ntion, e) the combination of the displacement in the circumferential direction and the provisi n of a cut-out in alternat guide vanes in accordance with th

invention; Fig. 4 illustrates the effect on the sound fr m the fan resulting from the axial displacement of the alternate guide vanes in accordance with the operational case c) in Fig. 3; Fig. 5 illustrates the effect on the sound level from the fan of the combination of axial displacement and displacement of the guide vanes in the circumferential direction of the guide vane ring according to the operational case d) in Fig. 3; Fig. 6 illustrates the reduction of sound in the tone at the blade frequency as a function of the rotation in the circumferential direction for a given axial displacement of the guide vanes; Fig. 7 illustrates an embodiment of the arrangement where two guide vane rings are used and Fig. 8 illustrates a particular guide vane configuration.

Fig. 2 illustrates an axial fan installed in a duct 4 and having a guide vane ring 2 arranged in spaced relationship with, and downstreams of the impeller 1. The number of guide vanes is preferably between 0,5 and 2,1 times the number of blades in the impeller.

In Fig. 1 the effects on the sound from a fan with guide vane arrangements according to the principles shown in figs. 3a and 3b are compared under the conditions given above. It will be seen from Fig. 1 that displacement of alternate guide vanes in the circumferential direction of the guide vane ring according to Fig. 3b results in a heavy decrease of a tone at the blade frequency 160 Hz, while there is an increase in the noise level for frequencies over about 500 Hz.

Fig. 4 compares the effect on the sound level of the guide vane arrangements according to figs. 3a and 3c. It will be seen that there is a considerable lowering of a tone at the blade frequency 160 Hz of about 3,5 dB, while there is an increase of the wide band high frequency noise over about 500 Hz. The operational conditions are the same as for Fig. 1.

In Fig. 5 the sound levels for the guide vane arrangements according to figs. 3a and 3d are compared. The surprising result will be seen from this figure that the combination of axial displacement and rotation in the circumferential direction of the ring of alternate guide vanes leads to a reduction of the sound level over the entire frequency range, compared with a conventional guide vane arrangement with uniformly

distributed guide vanes. Fig. 5 dem nstrates that both discrete tones at lower frequencies and the wide band high frequency noise are antenuated in an embodiment according to Fig. 3d. The axial displacement of the guide vanes is $1/1_{ch} = 0,5$, where 1 denotes the magnitude of the displacement and 1_{ch} the length along the guide vane, i.e. the displacement amounts to half the length of the guide vane. Rotation in the circumferential direction amounts to 10°. The curves are measured for a fan R.P.M. of n = 970.

In Fig. 6 there is illustrated the attenuation ΔL_W at the blade frequency, as a function of the rotation θ of alternate guide vanes in a guide vane arrangement where the alternate guide vane is also axially diplaced by half the length of the guide vane. The graphs are shown for two different revolutionary velocities of the fan, namely n = 970 rpm, and n = 1430 rpm. This diagram shows that considerable reduction of tonal components is achieved in the angle range 5-15° for the axial displacement of the guide vanes that is under consideration. Measurements have also shown that some improvement of the aerodynamic efficiency of the fan in the region where the best sound attenuation is achieved.

Another acoustically advantageous embodiment of the apparatus according to the invention is illustrated in Fig. 3e. In this embodiment a portion of the end part facing towards the impeller of alternate guide vanes is cut away, so that the forward edge of these guide vanes is at a first axial distance from the impeller and the remainder at a second axial distance. In addition, the guide vanes are non-uniformly distributed round the circumference of the ring.

In Fig. 7 there is illustrated a further advantageous embodiment of the guide vane ring 2 in the apparatus in accordance with the invention. The ring 2 is made up from two rings 20,22 mounted on a common shaft. Here, alternate guide vanes are carried by one of the two rings and the other by the other ring. The two rings are mutually axially displacable and relatively rotatable about the common shaft. With this embodiment of the guide vane ring 2 there is enabled in a simple way the axial displacement and circumferential rotation of the guide vanes relative each other s that desired properties are

achieved.

Fig. 8 illustrates an embodiment of a guide vane 6, which is found to be advantageous in the arrangement according to the invention. The end portion of the guide vane 10, which is intended to face towards the impeller has an edge 10 with a parabola-like configuration, so that between the inner and outer longitudinal edges 12 and 14 of the guide vane 6 there is a web with a shorter length L_2 along the guide vane than said edges L_1 and L_3, respectively. The guide vane has a straight back edge 16. If the height of the web from the inner longitudinal edge 12 is denoted by H_1 and the total height of the guide vane by H_2 the position of the web is determined by the condition:

$0,4 < H_1/H_2 < 0,9$,

and preferably $0,5 < H_1/H_2 < 0,8$

CLAIMS

1. Guide vane arrangement for axial fans, intended to translate the rotational component of the gas flow velocity after passage through the impeller into a substantially axial velocity, said arrangement including a ring of guide vanes arranged downstream of the fan and in spaced relationship therewith, **characterised** in that alternate guide vanes are axially displaced relative the remaining ones, so that alternate guide vanes are at a first axial distance from the fan and the remainder at a second axial distance.

2. Arrangement as claimed in claim 1, **characterised** in that the guide vanes are non-uniformly distributed along the circumference of the ring.

3. Guide vane arrangement for axial fans, intended to translate the rotational component of the gas flow velocity after passage through the impeller into a substantially axial velocity, said arrangement including a ring of guide vanes arranged downstream the fan and in spaced relationship therewith, **characterised** in that a portion of the end part facing towards the impeller of alternate guide vanes is cut away so that the forward edge of said guide vanes is at a first axial distance from the fan and the remainder of the guide vanes at a second axial distance, and in that the guide vanes are non-uniformly distributed along the circumference of the ring.

4. Arrangement as in either of claims 2 or 3, **characterised** in that alternate guide vanes are displaced in the circumferential direction relative the remaining guide vanes, with a constant displacement, so that the distance in the circumferential direction between adjacent guide vanes varies between two given values.

5. Arrangement as claimed in either of claims 1 or 2, **characterised** in that the axial displacement is in the interval 0,4-0,7 l/l_{ch}, preferably amounting to 0,5 l/l_{ch} where l denotes the magnitude of the displacement and l_{ch} the length of the guide vane.

6. Arrangement as claimed in any one of claims 2-5, **characterised** in that the displacement in the circumferential direction is in the interval 5-15°, preferably 10°.

7. Arrangement as claimed in any ne of 1-6, **characterised** in that the guide vane ring comprises tw rings axially in tandem, alternate guide vanes being carried by one ring and the remainder by the other ring, and in that these two rings are mutually axially displaceable and/or radially rotatable relative each other about a common axis.

8. Arrangement as claimed in any one of claims 1-7, **characterised** in that the guide vanes, in the part facing towards the fan, are formed with a web between the radially outer and inner portions of the guide vane, the arcuate length along the single-curved guide vane at the level of the web being shorter than at said outer and inner portions.

9. Arrangement as claimed in any one of claims 1-8, **characterised** in that the number of guide vanes is between 0,5 and 2,1 times the number of blades of the impeller.

AMENDED CLAIMS

[received by the International Bureau on 4 December 1992 (04.12.92) ; original claims 1-9 replaced by amended claims 1-9 (2 pages)]

1. Guide vane arrangement for axial fans, intended to translate the rotational component of the gas flow velocity after passage through the impeller (1) into a substantially axial velocity, said arrangement including a ring (2) of guide vanes arranged downstream of the fan and in spaced relationship therewith, **characterised** in that alternate guide vanes with the edge facing the impeller are axially displaced relative the remaining ones, so that alternate guide vanes are at a first axial distance from the fan and the remainder at a second axial distance, and in that the guide vanes are non-uniformly distributed along the circumference of the ring.

2. Arrangement according to claim 1, **characterised** in that a portion of the end part facing towards the impeller (1) of alternate guide vanes is cut away so that the forward edge of said guide vanes is at a first axial distance from the fan and the remainder of the guide vanes at a second axial distance.

3. Arrangement according to claim 1, **characterised in** that alternate guide vanes are axially displaced relative to the remaining guide vanes, so that the forward edge of alternate guide vanes are at first axial distance from the impeller and the remaining guide vanes are at a second axial distance.

4. Arrangement as in either of claims 2 or 3, **characterised** in that alternate guide vanes are displaced in the circumferential direction relative the remaining guide vanes, with a constant displacement, so that the distance in the circumferential direction between adjacent guide vanes varies between two given values.

5. Arrangement as claimed in either of claims 1 or 2, **characterised** in that the axial displacement is in the interval $1/1_{ch}$ = 0.4-0.7, preferably amounting to $1/1_{ch}$ = 0.5 where 1 denotes the magnitude of the displacement and 1_{ch} the length of the guide vane.

6. Arrangement as claimed in any one of claims 2-5, **characteris d** in that the displacement in the circumferential direction is in the interval 5-15°, preferably 10°.

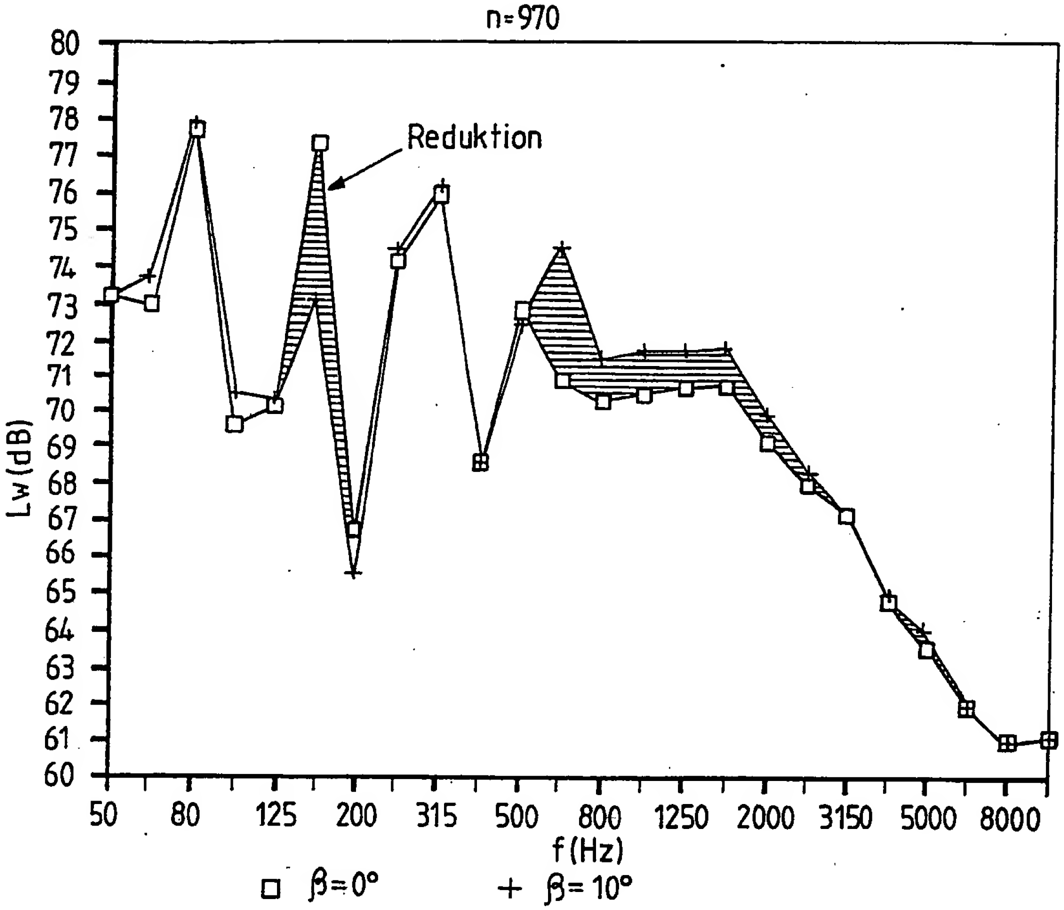
7. Arrangement as claimed in any one of 1-6, **characterised**

in that the guide vane ring (2) comprises two rings (20,22) axially in tandem, alternate guide vanes being carried by one ring and the remainder by the other ring, and in that these two rings are mutually axially displaceable and/or radially rotatable relative each other about a common axis.

8. Arrangement as claimed in any one of claims 1-7, **characterised** in that the guide vanes, in the part facing towards the fan, are formed with a web between the radially outer and inner portions of the guide vane, the arcuate length along the single-curved guide vane at the level of the web being shorter than at said outer and inner portions.

9. Arrangement as claimed in any one of claims 1-8, **characterised** in that the number of guide vanes is between 0.5 and 2.1 times the number of blades of the impeller.

Fig. 1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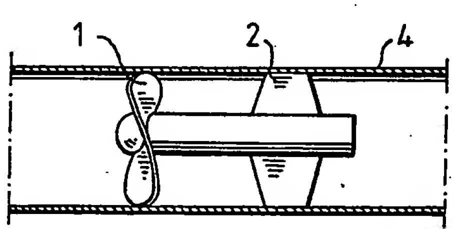
+ β=10°

Fig. 2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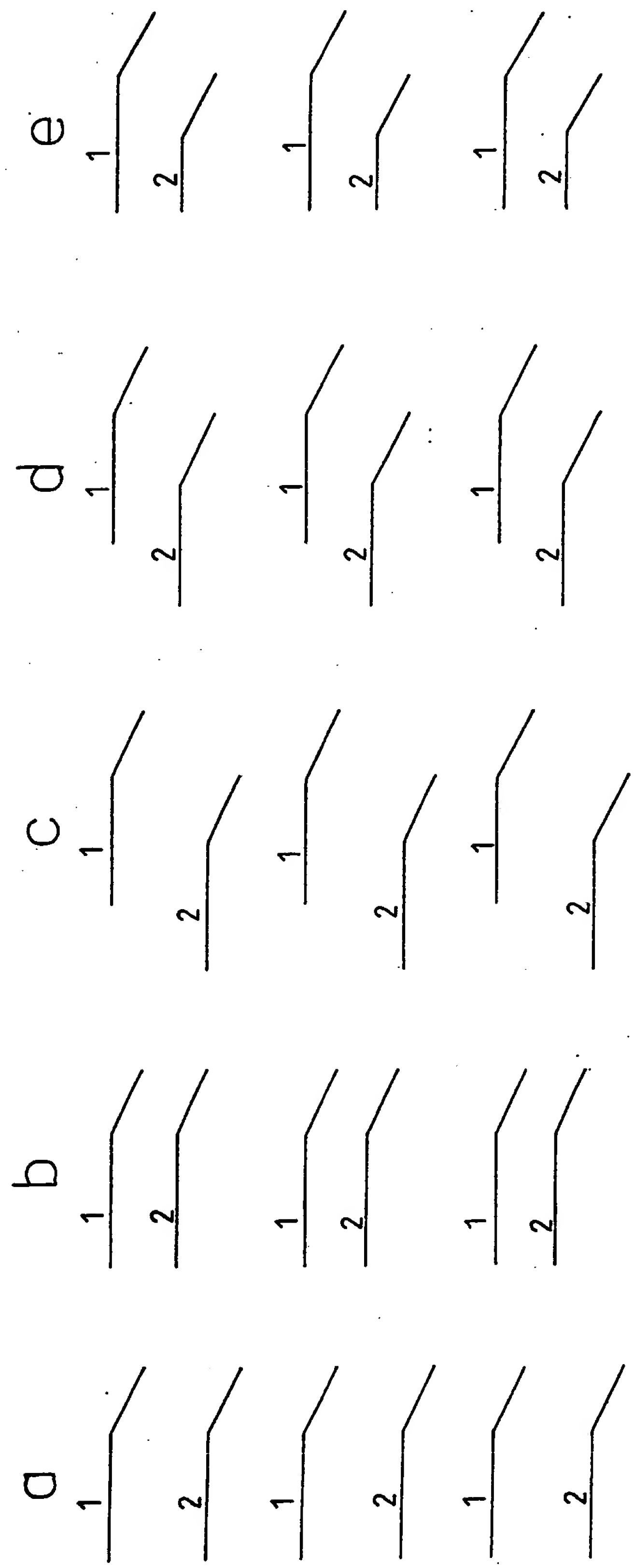

Fig. 3

Fig. 4

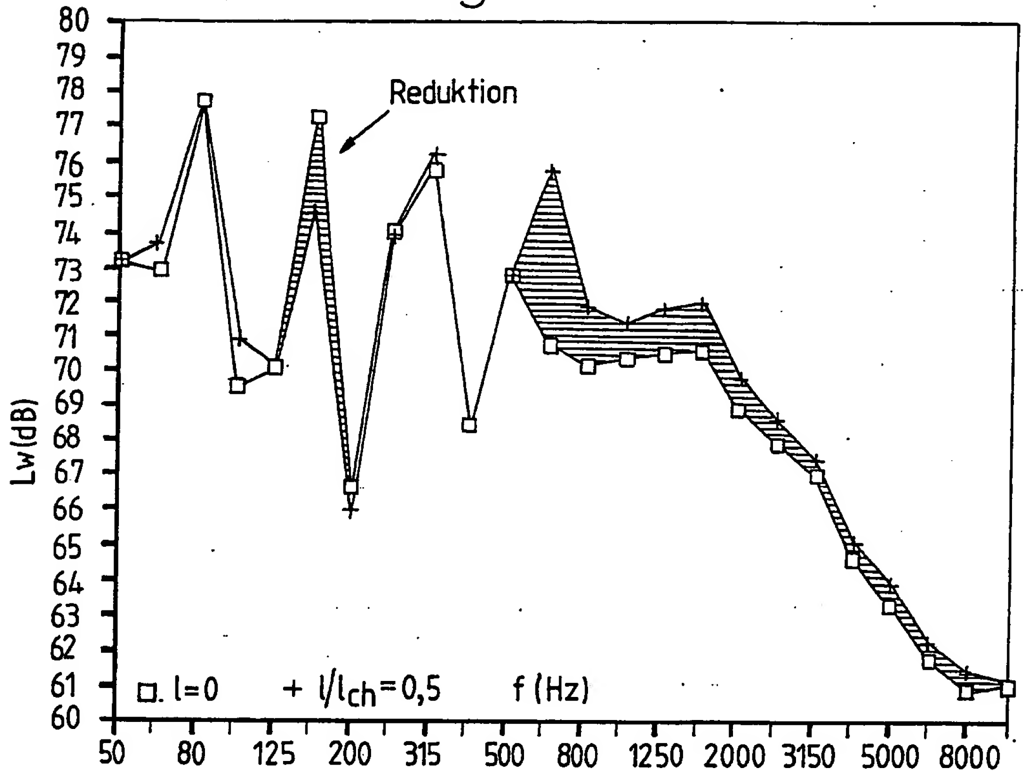
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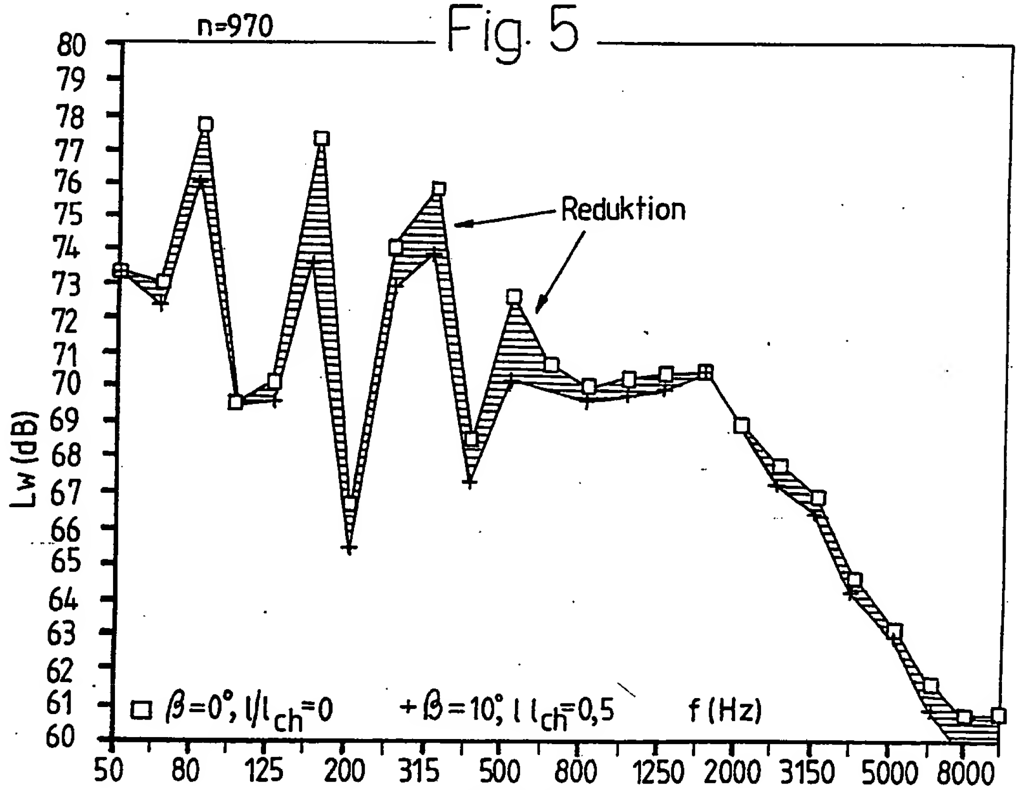
Fig. 5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3150
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Fig. 6

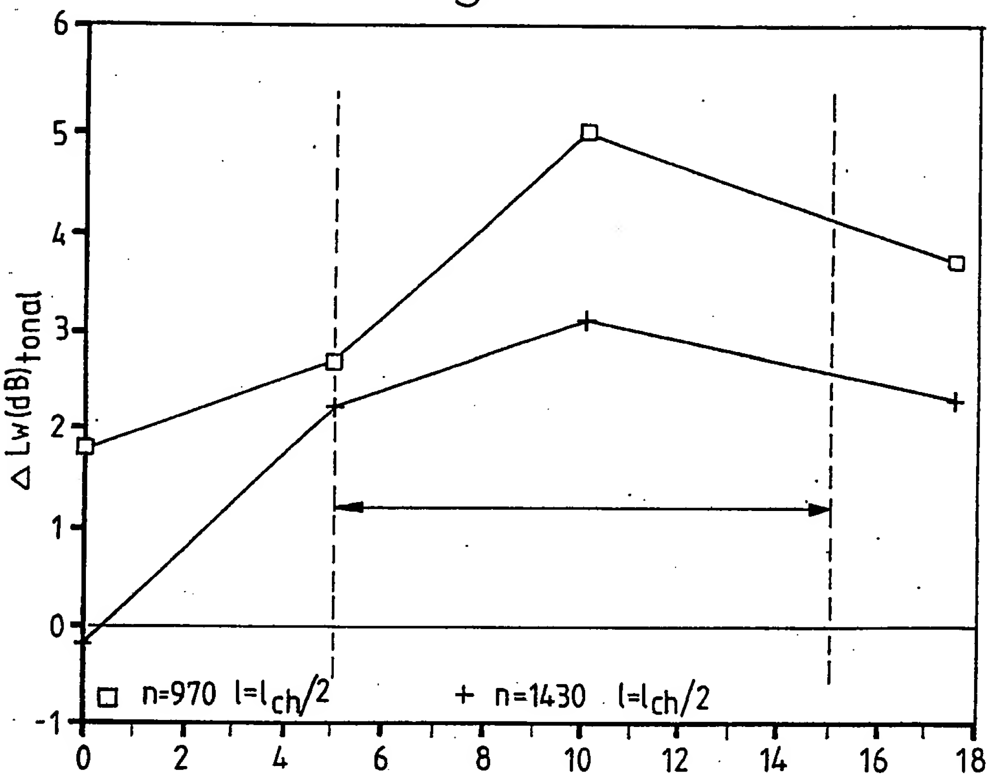


Fig. 7

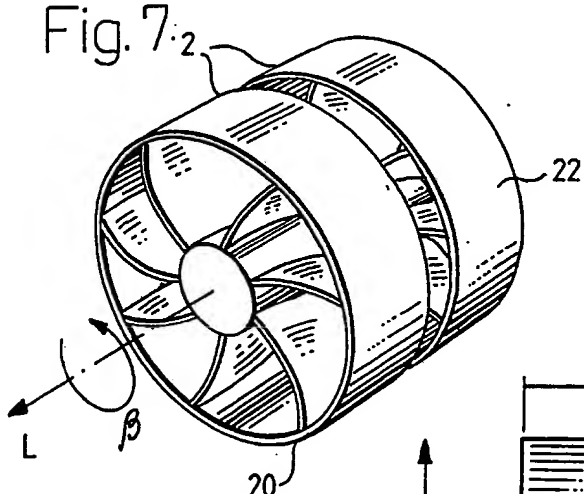
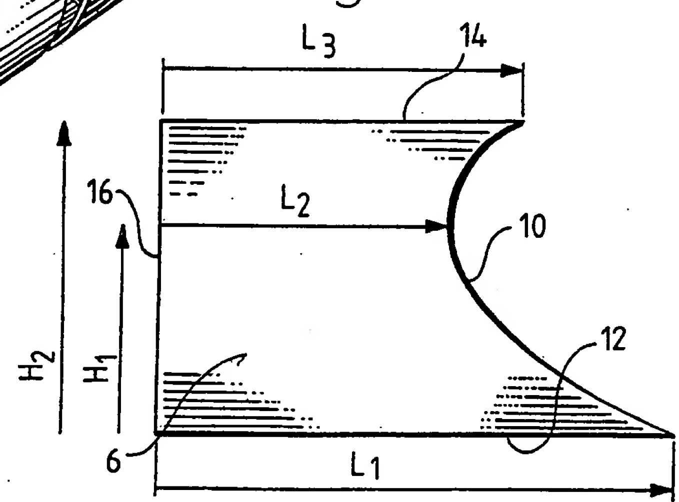


Fig. 8



INTERNATIONAL SEARCH REPORT

International Application No PCT/SE 92/00481

I. CLASSIFICATI N OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: F 04 D 29/54, 29/68

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	F 04 D

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X Y	US, A, 4720239 (OWCZAREK) 19 January 1988, see figure 3 --	1 2,3
X Y	US, A, 4981414 (SHEETS) 1 January 1991, see column 31, line 39 - line 52; figure 11 --	1 2,3
Y	1988 International Conference on Noise Control Engineering, inter-noise 88 Avignon, France, 30 August - 1 September 1988 Fan Noise-Generation Mechanisms and Control Methods (sid 767 - sid 776 (W. NEISE) see page 771, 3rd pharagraph --	2,3

* Special categories of cited documents: [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
5th October 1992	15 -10- 1992
International Searching Authority	**Signature of Authorized Officer**
SWEDISH PATENT OFFICE	Lena Nilsson Lena Nilsson

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FR M THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	WO, A1, 8912174 (FLÄKT AB) 14 December 1989, see abstract; figure 2 --	1,3
A	The Journal of the Acoustical Society of America 51 (1972):5, part 1 Research on Fan Noise Generation (page 1427 - page 1438) (M.J. BENZAKEIN) --	1,3

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.PCT/SE 92/00481

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the Swedish Patent Office EDP file on 28/08/92
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4720239	88-01-19	NONE	
US-A- 4981414	91-01-01	EP-A- 0343888	89-11-29
WO-A1- 8912174	89-12-14	AU-D- 3765289	90-01-05
		EP-A- 0418303	91-03-27
		JP-T- 3504996	91-10-31
		SE-B-C- 461112	90-01-08